

## CLAIMS

We CLAIM:

1        1. A data structure for scheduling one or more event queues, comprising:  
2            a scheduler having a current time and a current epoch bit;  
3            a first event queue having a first event, the first event including a first time stamp,  
4            the first time stamp being associated with a first epoch bit; and  
5            a second event queue having a first event, the first event of the second event  
6            queue including a first time stamp, the first time stamp being associated with a first epoch  
7            bit; wherein the data structure determines a real time by comparing the current epoch bit  
8            with the first epoch bit of the first event queue and the first epoch bit of the second event  
9            queue.

1        2. The data structure of Claim 1, wherein the first time stamp of the first event in  
2            the first event queue compares with the first event in the first time stamp of the first event  
3            in the second event queue if the first epoch bit associated with the first time stamp of the  
4            first event in the first event queue is equal to the first epoch bit associated with the first  
5            time stamp of the first event in the second event queue.

1        3. A method for scheduling one or more event queues and for resolving  
2            timestamp rollover conflicts, comprising:  
3            providing a first bit assigning to a scheduler;  
4            providing a second bit that corresponds to an event queue;

10                         comparing the current epoch to determine timestamp rollover conditions by  
11                         alternately considering the following comparisons of epoch bits to be true when each time  
12                         counter rolls over.

1                         4. A data structure for scheduling and arbitration, comprising:  
2                                 in a root node of a heap tree or similar data structure, comprising:  
3                                         a first sort index for determining priority of a first event; and  
4                                         a first data field, concatenated to the first sort index, having a first  
5                                 queue identifier associated with the event; and  
6                                         in a second level, relative to the root node, of the heap tree or similar data  
7                                 structure, comprising:  
8                                         a second node with a second sort index for determining priority of  
9                                         a second event and a second data field, concatenated to the second sort index, and having  
10                                         a third node with a third sort index for determining priority of a third event; and a third  
11                                         data field, concatenated to the third sort index, having a third queue identifier associated  
12                                         with the third event.

1                         5. A method for strict priority scheduling in a pile, comprising:  
2                                 in a first event in a first node, comprising:  
3                                         providing a first queue having a first sort index and a first data field, the  
4                                         first sort index including a first priority and the first data field including a first event  
5                                         queue identifier;

6 in a second event in a second node, comprising:  
7 providing a second queue having a second sort index and a second data  
8 field, the second sort index including a first priority and a second data field including a  
9 second event queue identifier;  
10 determining a priority between the first queue and the second queue based on the  
11 first priority in the first queue and the second priority in the second queue; and  
12 activating the first queue if the first priority is a higher priority than the second  
13 priority and activating the second queue if the second priority is a higher priority than the  
14 first priority.

1 6. The method of Claim 5, wherein the value of the first priority in the first sort  
2 index is equal to the value of the first event queue identifier in the first data field.

1 7. The method of Claim 5, wherein the value of the second priority in the  
2 second sort index is equal to the value of the second event queue identifier in the second  
3 data field.

1 8. The method of Claim 5, further comprising removing an event from a root  
2 node if the first queue in the first event is not empty by rescheduling the event, and  
3 percolating a node corresponding to the event down to a location in a heap-like tree  
4 structure.

1 9. The method of Claim 5, further comprising removing an event from a root  
2 node if the first queue in the first event is empty by removing the first priority of the first

3 event in the first node; and leaving an empty node in the first node to percolate down a  
4 heap-like structure.

1 10. The method of Claim 5, further comprising inserting an event in the pile by  
2 assigning a designated priority corresponding to a particular queue, and placing the  
3 designated priority and a corresponding identifier in a node.

1 11. A method for ensuring weighted fair queuing in a heap-like tree structure,  
2 comprising:

3 allocating a first service time duration to a first queue having a first event; and  
4 allocating a second service time duration to a second queue having a second  
5 event;

6 if no more events are present in the first queue, comprising:

7 removing the first queue;  
8 redistributing the first service time duration;

9 if no more events are present in the second queue, comprising:

10 removing the second queue;  
11 redistributing the second service time duration.

1 12. The method of Claim 11, wherein the redistributing of the first service time  
2 duration comprises redistributing remaining event queues proportional to a service rate  
3 associated with the second queue and other queues excluding the first queue.

1           13. The method of Claim 11, wherein the redistributing of the second service  
2 time duration comprises redistributing remaining event queues proportional to a service  
3 rate associated with the first queue and other queues excluding the second queue.

1           14. The method of Claim 11, further comprising removing an event from a root  
2 node if the first queue in the first event is not empty by rescheduling the event, and  
3 percolating a node corresponding to the event down to a location in a heap-like tree  
4 structure.

1           15. The method of Claim 11, further comprising removing an event from a root  
2 node if the first queue in the first event is empty by removing the first priority of the first  
3 event in the first node; and leaving an empty node in the first node to percolate down a  
4 heap-like structure.

1           16. The method of Claim 11, further comprising inserting an event in a pile  
2 including:

3                   computing a time required to dispatch an event;  
4                   placing a queue identifier of the event, and the time to dispatch the event,  
5                   in a root node of a heap-like tree structure; and  
6                   percolating the node down in the pile.

1           17. The method of Claim 11, further comprising rescheduling an event queue  
2 including:  
3                   computing a time required to dispatch a next event in a same queue; and

4 replacing an old timestamp associated with the event with a new  
5 timestamp; and  
6 percolating the node down to a heap-like tree structure.

18. A method for traffic shaping in a pile, comprising:

in a first node, comprising:

a first queue having a first sort index and a first data field, the first sort index having a first priority and a first timestamp, the first timestamp representing a next transmission time for the first queue in the first node, the first data field having a first event queue identifier, the first queue being given a maximum average rate of transmission; and

in a second node, comprising

a second entry having a second sort index and a second data field, the second sort index having a second priority and a second timestamp, the second timestamp representing a next transmission time for the second queue in the second node the second data field having a second event queue identifier, the second queue being given the maximum average rate of transmission.

**19. A method for scheduling and arbitrating events, comprising:**

2 in a root node in a heap-like data structure, comprising:

3 storing an event A in a first event queue having a first priority;

4 in a second level relative to the root node, comprising:

5                   storing an event C in a second event queue having a second priority; and  
6                   dispatching the event A if the first priority is higher priority than the  
7                   second priority, or dispatching the event C if the second priority is high priority than the  
8                   first priority .

1            20. The method of Claim 19, further comprising storing an event B after the  
2            event A in the first even queue.

1            21. The method of Claim 19, further comprising storing an event D, an event E,  
2 and an event F in a third event queue.

22. A method for inserting an event, comprising

providing a node having a first event queue identifier and a first timestamp;

and

placing the node at the root node.

1 24. A method for removing an event, comprising

2 providing a root node having an event including a next event queue;

removing the event from the root node, thereby leaving a hole in the root node;

4 and

5 percolating the hole to a location in a heap-like data structure.

- 1 25. A method for rescheduling an event, comprising:
  - 2 assigning a first timestamp and a first identifier to a first node;
  - 3 assigning second time stamp and a second identifier to a second node;
  - 4 rescheduling the first node by assigning a new timestamp in place of the first
  - 5 timestamp; and
  - 6 percolating the first node to a location in a heal-like data structure.

1        26. A data structure system, comprising:

2            a memory queue, for storing a packet to be transmitted onto an Internet link;

3            a transmission time calculator, for computing a transmission time of the packet;

4            a queue parameter table for determining the transmission time on the basis of a

5            specified service rates or hard-coded properties; and

6            a pile manipulation pipeline, for storing the transmission time and a queue

7            identifier associated with the packet, and for transmitting the packet when sufficient

8            transmission time has elapsed in a root node of a heap like data structure.

- 1        27. A multiple piles in a random access memory (RAM), comprising:
  - 2                in a RAM having a pile data structure, comprising
    - 3                        a first pile, having a first root node representing a first scheduler;
    - 4                        a second pile, linking to the first pile, having a second root node representing
      - 5                                a second scheduler